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ELECTRIC DRIVE UNIT FOR GENERATING AN OSCILLATING  
MOVEMENT

TECHNICAL FIELD

~~The invention pertains~~ This application relates to an electric drive unit for generating an oscillating movement. ~~The invention furthermore pertains to a small electric appliance with such a drive unit, as well as a method for manufacturing a corresponding drive unit.~~

BACKGROUND

Drive units for generating an oscillating movement are used, for example, in electric toothbrushes or electric razors. For example, Patent No. DE 28 20 437 A1 discloses an electric toothbrush with an oscillating armature motor. The oscillating armature motor is used for realizing an oscillating rotational movement of a shaft that carries a brush element. The rotational movements are influenced by torsion springs and damping elements such that a desired motion sequence is adjusted.

~~An~~ U.S. Patent No. 5,613,259 discloses an oscillating appliance, ~~particularly~~ i.e., in the form of an electric toothbrush, is also known from US 5,613,259. This appliance features a mechanical oscillator that is driven by an electric motor. The electric motor is controlled in dependence on the oscillating frequency of the mechanical oscillator that is determined by means of a sensor, such that the mechanical oscillator ~~also~~ remains resonant under a varying load. The mechanical oscillator is realized in the form of a spring-mass system that may comprise a coil spring or a torsion rod.

In order to achieve a ~~largely~~substantially optimal operation of the electric drive unit for generating an oscillating movement, the drive unit should be excited with a frequency that ~~largely~~substantially corresponds or lies close to its resonant frequency. However, the resonant frequency not only changes with the load of the drive unit, but is also detuned due to manufacturing tolerances associated with series production. Although regulating the excitation frequency can compensate for this detuning ~~can be compensated by regulating the excitation frequency~~, such a ~~control~~ results in increased manufacturing costs. ~~In addition~~Moreover, a ~~change of~~changing the excitation frequency is undesirable in certain applications.

#### SUMMARY

~~Consequently, the invention is based on the objective of realizing a largely optimal electric drive unit for generating an oscillating movement with the least expenditure possible.~~

~~This objective is attained with the combination of characteristics disclosed in Claim 1.~~

~~The inventive~~ In one aspect, an electric drive unit for generating an oscillating movement ~~features~~has a stator, a rotor and a torsion element. ~~The peculiarity of the drive unit according to the invention can be seen in that~~ Moreover, a tuning element is provided that acts upon the torsion element, ~~and serves for serving to mechanically tuning~~tune the resonant frequency of the drive unit.

~~The invention provides~~ Certain implementations may have the advantage that the drive unit allows for an optimal

conversion of the electric driving energy into the oscillating movement regardless of possible manufacturing tolerances, such that a comparatively low electrical power suffices for the operation of the ~~inventive~~-drive unit.

The ~~—drive unit according to the invention—is~~ preferably realized such that the tuning element fixes the torsion element at a variable location of the torsion element. ~~In this case, the~~ tuning element may be arranged on the stator, such that it can be displaced and fixed in position. The tuning element, ~~in particular, may~~ element may be displaceable parallel to the longitudinal axis of the drive unit. For this purpose, the tuning element may engage, for example, into at least one groove in the stator. A design of this type can be realized with a relatively low expenditure, and makes it possible to easily tune the resonant frequency of the ~~inventive~~-drive unit.

With respect to its simple handling, it ~~is—can be~~ particularly advantageous ~~that—to provide~~ the tuning element ~~is—realized—in~~ the form of a clamping device. In this case, the tuning element may ~~comprise~~have, for example, two parts and at least one connecting element for pulling together the two parts.

The torsion element ~~is—usually—can be~~ fixed on the rotor. In one preferred ~~embodiment—implementation of~~ the drive unit ~~according to the invention~~, the rotor features a hollow shaft. In this case, it ~~is—can be~~ particularly advantageous ~~that—to arrange~~ the torsion element ~~is—can be—~~at least partially, ~~—arranged~~ within the hollow shaft. ~~This makes,~~ making it possible to ~~realize—provide~~ the ~~inventive~~-drive unit in a very compact fashion. The torsion element ~~is—preferably—can be realized—provided~~ in the form of a torsion rod that

can be manufactured with very strict tolerances and hardly requires any structural space, particularly when implemented in combination with the hollow shaft.

~~The inventive drive unit~~ may feature a housing with a recess in the region of the tuning element. This makes it possible to carry out the tuning of the resonant frequency when the drive unit ~~according to the invention~~ is already completely assembled.

In one preferred embodiment of the ~~inventive drive~~ unit, the stator features permanent magnets and at least one coil. The rotor preferably features an armature of a magnetizable material.

~~The invention furthermore pertains to~~In aAnother aspect of the invention features, a small electric appliance ~~can be~~ equipped with the above-described inventive drive unit. The small appliance ~~according to the invention~~ iscan be preferably realized in the form of an electric toothbrush or an electric razor. Appliances of this type are frequently operated independently of the electric power supply by means of a battery. ~~such that the~~The comparatively low power consumption of the ~~inventive drive~~ unit has positive effects on the time of operation that can be achieved with one battery charge.

~~The inventive method~~Another aspect of the invention features a method of manufacturing ~~pertains to the manufacture of an~~ electric drive unit for generating an oscillating movement, ~~wherein the~~The drive unit features a stator, a rotor and a torsion element. The ~~peculiarity of the method according to the invention~~ can be seen in that the resonant frequency of the drive unit is mechanically tuned by the torsion element after the assembly of the drive unit.

The scope of the method ~~according to the invention~~ includes embodiments, in which a region of the torsion element that participates in the oscillating movement can be varied in order to adjust the drive unit to a desired resonant frequency. For this purpose, the torsion element can be fixed on a tuning element, ~~wherein the~~ The location at ~~which~~ where the tuning element engages on the torsion element ~~is~~ can be chosen such that the drive unit has the desired resonant frequency. In order to achieve a reliable tuning of the resonant frequency, the drive unit ~~is~~ can be excited, such that it carries out an oscillating movement, and the location of the torsion element at ~~which~~ where the tuning element needs to be fixed ~~is~~ can be determined from the oscillating movement of the drive unit. In one preferred embodiment of the ~~inventive~~ method, an excitation by pulses is ~~used~~ employed for ~~causing to~~ cause the oscillation of the drive unit. The location of the torsion element at ~~which~~ where the tuning element needs to be fixed can be determined, for example, from the decay behavior of the oscillating movement. The torsion element is preferably fixed in the rotational position that the rotor assumes when the drive unit is switched off.

~~The invention is described in greater detail below with reference to the embodiments that are illustrated in the figures and in which the inventive drive unit is respectively intended for use in an electric toothbrush. Other aspects, features, and advantages will be apparent from the following detailed description, the drawings, and the claims.~~

#### DESCRIPTION OF DRAWINGS

~~The figures show:~~

Figure 1, is a top view of a first embodiment of a drive unit ~~realized in accordance with the invention;~~

Figure 2, is a longitudinal section through the first embodiment of the ~~inventive~~ drive unit along the line A-A in Figure 1;

Figure 3, is another longitudinal section through the first embodiment of the ~~inventive~~ drive unit, wherein the plane of section is turned relative to Figures 2 by 90° about the longitudinal axis of the ~~inventive~~ drive unit;

Figure 4, is a cross section through the first embodiment of the ~~inventive~~ drive unit along the line B-B in Figure 1;

Figure 5, is a cross section through the first embodiment of the ~~inventive~~ drive unit along the line C-C in Figure 1, and

Figure 6, is a cross section through a second embodiment of the ~~inventive~~ drive unit along the line C-C in Figure 1.

#### DETAILED DESCRIPTION

~~Figure 1 shows a top view of an embodiment of a drive unit 1 that is realized in accordance with the invention. The~~Referring to Figure 1, drive unit 1 features an elongated housing 2, from one face of which a hollow shaft 3 protrudes, ~~that extends~~extending parallel to the longitudinal axis of the drive unit 1. A connection piece 4 for receiving a not-shown toothbrush attachment is coaxially inserted into the

axial end of the hollow shaft 3 that is situated outside the housing 2, and then connected to the hollow shaft 3 in a rotationally rigid fashion. The housing 2 features a window-shaped recess 5 on one of its longitudinal sides, ~~namely for example in the end region opposite end region referred to the face on~~ which the hollow shaft 3 protrudes from the housing 2. An adjusting element 6 arranged in the interior of the housing 2 is visible through the recess 5, wherein this adjusting element can be displaced parallel to the longitudinal axis of the drive unit 1, and is described in greater detail ~~further~~ below. Details regarding the internal design of the drive unit 1 are illustrated in the sectional representations according to Figures 2-5, and in the sectional representation of a second embodiment according to Figure 6.

~~Referring to Figure 2 shows a longitudinal section through the first embodiment of the drive unit 1 along the line A A in Figure 1. Figure 3 shows another longitudinal section, in which the plane of section is turned relative to Figure 2 by 90° about the longitudinal axis of the drive unit 1. According to~~ Figures 2 and 3, the hollow shaft 3 continues into the housing 2 and is rotatably supported relative to the housing 2 in two bearings 7. The bearings 7 are arranged in a coil form 8. An armature 9 is arranged on the hollow shaft 3 in a rotationally rigid fashion between the two bearings 7. A torsion rod 10 extends within the hollow shaft 3 coaxial to the hollow shaft 3 and protrudes from the hollow shaft 3 with both of its axial ends. In the region of its first axial end, the torsion rod 10 is connected to the connection piece 4, and therefore also to the hollow shaft 3 in a rotationally rigid fashion. In the vicinity of its second axial end, the torsion rod 10 is clamped into the adjusting element 6 in a rotationally rigid

fashion, and thus ~~[[ly]]~~ connected to the housing 2 in a rotationally rigid fashion. This means that a torsionally elastic suspension of the hollow shaft 3 including the connection piece 4 and the armature 9 is can be realized on the housing 2 by means of the torsion rod 10.

Permanent magnets 12 are arranged radially adjacent to the armature 9 on carrier plates 11. The carrier plates 11 are arranged on the inside of the housing 2 diametrically opposite of one another. A stationary stator 13 and a rotor 14 that is rotatable relative to the stator 13 are realized with the components illustrated in Figures 3 and 4. The housing 2, the coil form 8, the carrier plate 11 and the permanent magnets 12 can be assigned to the stator 13. The hollow shaft 3 with the connection piece 4 and the armature 9 form the components of the rotor 14. The stator 13 and the rotor 14 are coupled to one another in a torsionally elastic fashion with the aid of the torsion rod 10.

~~Figure 4 shows a cross section through the first embodiment of the drive unit 1 along the line B-B in Figure 1. According~~ Referring to Figure 4, the armature 9 has an elongated cross-sectional shape and is arranged in an oblong hollow space 15 in such a way that it can be slightly turned in both rotating directions relative to the idle position shown. ~~The~~ In this implementation, the coil form 8 carries at least one coil 16 that is only partially illustrated in Figure 4. When a current flows through the coil 16, a magnetic field is generated in the armature 9, such that a magnetic interaction with the permanent magnets 12 occurs in the region of the radial surfaces of the armature 9 that are situated adjacent to the permanent magnets 12, ~~wherein this~~ This magnetic interaction causes the armature 9 to be displaced from its idle



position, and therefore the hollow shaft 3 to be slightly turned. An alternating current feed to the coil 16 makes it possible to achieve an alternating movement of the armature 9 in both rotating directions referred to its idle position, such ~~the~~ that an oscillating rotational movement of the rotor 14 occurs. This oscillating rotational movement is promoted by the torsion rod 10 that respectively turns the rotor 14 back into the idle position of the armature 9 and forms an oscillatory spring-mass system together with the rotor 14.

The amplitude of the oscillating rotational movement becomes particularly high if the excitation, by means of the current-carrying coil 16, takes place ~~with~~ at the resonant frequency of the spring-mass system. The excitation energy can be transmitted most effectively within the range of the resonant frequency, such that the excitation energy required for a desired amplitude assumes a minimum value. In order to operate the drive unit 1 as efficiently as possible, the resonant frequency of the spring-mass system should correspond as precisely as possible to the excitation frequency, or to a predetermined value in the vicinity of the excitation frequency. However, in in the series production of several drive units 1, ~~however,~~ the resonant frequencies are detuned due to manufacturing-related tolerances of the components forming the drive unit 1. ~~In order to solve this problem, the invention proposes that~~ In a preferred implementation, the resonant frequency of the spring-mass system ~~is~~ can be mechanically tuned after its assembly. The tuning ~~is~~ can be respectively achieved by varying in that the effective length of the torsion rod ~~is varied~~ with the aid of the adjusting element 6. This procedure is discussed in detail below with reference to Figure 5.

Figure 5 shows a cross section through the first embodiment of the drive unit 1 along the line C-C in Figure 1. Consequently, the plane of section extends through the adjusting element 6 that consists of an upper part 17 and a lower part 18. The parting plane between the upper part 17 and the lower part 18 of the adjusting element 6 extends parallel to the longitudinal axis of the drive unit 1. The upper part 17 of the adjusting element 6 engages into one respective groove 19 in the coil form 8 that extends parallel to the longitudinal axis of the drive unit 1 on both sides, and can be moved in this direction only.

The upper part 17 is screwed to the lower part 18 with two screws 20 that are inserted into through-bores 21 in the upper part 17 of the adjusting element 6 and engage ~~into~~ threaded bores in the lower part 18 of the adjusting element 6. When the screws are tightened, the torsion rod 10 is clamped between two splines 23 that are realized parallel to the longitudinal axis of the drive unit 1 in the upper part 17, and in the lower part 18 of the adjusting element 6. ~~and the~~ The wall surfaces of ~~which the splines~~ are pressed against the cylindrical outer surface of the torsion rod 10. This causes the torsion rod 10 to be non-positively fixed on the adjusting element 6. The adjusting element 6 is simultaneously blocked from moving parallel to the longitudinal axis of the drive unit 1 because the torsion rod 10 is rigid in this direction. The screws 20 are accessible through the recess 5 in the housing 2 in order to be tightened and loosened. The tuning of the resonant frequency of the spring-mass system of the drive unit 1 can be carried out as described below—.

The torsion rod 10 is clamped into the adjusting element 6 in the rotational position that it assumes as its idle position due to the effect of the permanent

magnets 12 on the armature 9. Before the torsion rod 10 is fixed in position by tightening the screws 20, a preliminary tuning process ~~is~~ can be carried out by displacing the adjusting element 6 into the position in which the desired resonant frequency of the spring-mass system is presumably reached. In this case, the effective length of the torsion rod 10 is adjusted with the aid of the adjusting element 6, such that the resonant frequency of the spring-mass system is influenced accordingly. The effective length of the torsion rod 10 corresponds to the distance between the location at which the torsion rod 10 is fixed on the connection piece 4 and the location at which the torsion rod 10 is fixed on the adjusting element 6. The resonant frequency rises when the effective length of the torsion rod 10 is shortened, i.e., if the adjusting element 6 is displaced toward the hollow shaft 3. Vice versa, the resonant frequency is lowered if the effective length of the torsion rod 10 is extended by increasing the distance between the adjusting element 6 and the hollow shaft 3.

After this preliminary adjustment, the drive unit is excited by pulses such that it carries out an oscillating movement, and the effective resonant frequency of the spring-mass system for the current position of the adjusting element 6 is determined from the decay behavior of the oscillating movement. The deviation between the effective resonant frequency and the desired resonant frequency is then used for determining the distance, by which the adjusting element 6 needs to be displaced in order to reach the desired resonant frequency, for example, with the aid of an empirically prepared table. The adjusting element 6 is then displaced by the determined distance. The position of the adjusting element 6 can be checked with another excitation by pulses. If so required, the

adjusting element 6 is readjusted until the effective resonant frequency of the spring-mass system corresponds to the desired resonant frequency with a predetermined accuracy. The adjusting element 6 is then permanently fixed in position.

According to Figures 4 and 5, the torsion rod 10 according to the first embodiment of the ~~inventive~~ drive unit 1 has a circular cross section. The scope of the invention also includes alternative designs of the torsion rod 10. ~~One possible variation is~~ Other implementations are possible, for example a second embodiment is illustrated in Figure 6.

~~Figure 6 shows a cross section through a second embodiment of the drive unit 1 along the line C-C in Figure 1. The~~ Referring to Figure 6, the torsion rod 10 has a square cross section in the second embodiment. The departure from the rotationally symmetrical design of the torsion rod 10 in the second embodiment makes it possible to positively secure the torsion rod 10 with the adjusting element 6 from turning. The splines 23 used in the first embodiment for fixing the torsion rod in the upper part 17 and the lower part 18 of the adjusting element 6 may also be used in this case. The second embodiment of the drive unit 1 also corresponds to the first embodiment with respect to its remaining design and its function.

Other implementations are within the scope of the following claims.

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CLAIMS

1. (Currently Amended)An electric drive unit for generating an oscillating movement, the drive unit that ~~comprises~~comprising:  
a stator ~~(13)~~; i  
a rotor ~~(14)~~; i  
a torsion element ~~(10)~~; and  
a tuning element, which ~~(6)~~ that acts upon the torsion element ~~(10)~~ and serves for mechanically tuning the resonant frequency of the drive unit ~~(1)~~, ~~characterized in that~~ wherein the rotor ~~(14)~~ features ~~comprises~~ a hollow shaft ~~(3)~~, and ~~in that~~ wherein the torsion element ~~(10)~~ is at least partially arranged within the hollow shaft ~~(3)~~.
2. (Currently Amended)The drive unit according to claim 1, ~~characterized in that~~ wherein the tuning element ~~(6)~~ ~~fixes~~ is arranged to secure the torsion element ~~(10)~~ ~~at a variable location of the~~ torsion element in a selectable position ~~(10)~~.
3. (Currently Amended)The drive unit according to ~~one of the preceding claims~~ claim 2, ~~characterized in that~~ wherein the tuning element ~~(6)~~ is arranged on the stator ~~(13)~~ such that it can be displaced and fixed in position.
4. (Currently Amended)The drive unit according to claim 3, ~~characterized in that~~ wherein the tuning element ~~(6)~~ is displaceable parallel to the longitudinal axis of the drive unit ~~(1)~~.
5. (Currently Amended)The drive unit according to claim 3 ~~or 4~~, ~~characterized in that~~ wherein the tuning element ~~(6)~~ engages into at least one groove ~~(19)~~ in the stator ~~(13)~~.

6. (Currently Amended)The drive unit according to one of the preceding claims claim 1, ~~characterized in that wherein~~ the tuning element ~~(6)~~ is realized in the form of comprises a clamping device.
7. (Currently Amended)The drive unit according to claim 6, ~~characterized in that wherein~~ the tuning element comprises two parts ~~(17, 18)~~ and at least one connecting element ~~(20)~~ for pulling together configured to draw the two parts ~~(17, 18)~~ together.
8. (Currently Amended)The drive unit according to one of the preceding claims claim 1, ~~characterized in that wherein~~ the torsion element ~~(10)~~ is fixed on the rotor ~~(14)~~.
9. (Currently Amended)The drive unit according to one of the preceding claims claim 1, ~~characterized in that wherein~~ the torsion element ~~(10)~~ is realized in the form of comprises a torsion rod.
10. (Currently Amended)The drive unit according to one of the preceding claims claim 1, ~~characterized in that further comprising~~ a housing ~~(2)~~ is provided that features having a recess ~~(5)~~ in the region of arranged to accommodate the tuning element ~~(6)~~.
11. (Currently Amended)The drive unit according to one of the preceding claims claim 1, ~~characterized in that wherein~~ the stator ~~(13)~~ features comprises permanent magnets ~~(12)~~ and at least one coil ~~(16)~~.
12. (Currently Amended) The drive unit according to one of the preceding claims claim 1, ~~characterized~~

~~in that wherein~~ the rotor (14) ~~features~~ comprises  
an armature (9) ~~of a magnetizable material.~~

13. (Currently Amended) A small electric appliance,  
~~characterized in that it features a~~comprising  
drive unit (1) ~~according to one of the preceding~~  
~~claims~~of claim 1.
14. (Currently Amended) The small appliance according  
~~to of~~claim 13, ~~characterized in that it is~~  
~~realized~~ in the form of an electric toothbrush or  
~~in the form of an electric razor.~~
15. (Currently Amended) A method for of manufacturing  
an electric drive unit (1) ~~for~~ generating an  
oscillating movement, wherein the drive unit (1)  
comprises a stator (13), a rotor (14), a torsion  
element (10) and a tuning element (6), and wherein  
the resonant frequency of the drive unit (1) is  
mechanically tuned, ~~characterized in that the~~  
method comprising:  
exciting the drive unit (1) is excited such that  
it carries out to generate an oscillating movement,  
; and  
determining from the oscillating movement a  
desired in that the location on of the torsion  
element (10) at which for securing the tuning  
element (6) needs to be fixed is determined from  
the oscillating movement to tune a resonant  
frequency of the drive unit.
16. (Currently Amended) The method according to of  
claim 15, ~~characterized in that further~~  
comprising:  
fixing the torsion element (10) is fixed on the  
tuning element (6), wherein ; and  
choosing the location at which the tuning element

~~(6) engages on the torsion element, (10) is chosen such that the drive unit (1) has the desired resonant frequency in the desired location.~~

17. (Currently Amended)The method according to claim 16, ~~characterized in that~~ wherein exciting the drive unit (1) carries out the oscillating movement due to ~~comprises~~ excitation exciting the drive unit by pulses.
18. (Currently Amended)The method according to ~~one of~~ claims claim 15-17, characterized in that further comprising switching the drive unit off, and then fixing the torsion element ~~(10) is fixed in the a~~ rotational position that the rotor ~~(14) assumes~~ when the drive unit ~~(1) is~~ switched off.



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ABSTRACT

~~The invention pertains to an~~An electric drive unit (1)  
for generating an oscillating movement. ~~The inventive~~  
~~drive unit (1) comprises~~movement, having a stator (13),  
a rotor, (14) ~~and a~~ torsion element and a tuning  
element. (10) and is characterized in that a The tuning  
~~element (6) is provided that acts upon the torsion~~  
~~element (10) and serves for to mechanically tuning-tune~~  
the resonant frequency of the drive unit (1).

~~(Figure 2)~~